SOME NEW BOOKS.

The Latest Book on Evolution.

FIRST NOTICE.

We commend to a careful perusal the work entitled *Problems of Evolution*, by F. W. HEADLEY (T. Y. Crowell & Co.). The author may be described as a Neo-Darwinian, but he is by no means an undiscriminating follower of Weismann. His mind is stored with all the knowledge relating to the subject, and he thinks for himself; his conclusions even when not accepted will command respectful consideration. The purpose of the book is to find a solution of some of the most difficult of the problems of evolution. Mr. Headley first tries to show that Lamarck's explanation of evolution will not bear investigation. If, however, the dovetailing of species into their environment has not been brought about as Lamarck maintained that it had, by the moulding influence of the environment itself and the development of the organism by exercise, how have adaptations been effected? To account for them the Neo-Darwinian, the follower of Weismann, has at his service only variations—he assumes that a tendency to vary pervades the whole organic world—and, as a regulating principle, Natural Selection. The author essays to make clear that nothing further is needed to account for all the niceties of adaptation. To the first part of the book, which deals with evolution in general, Mr. Headley has prefixed an introductory chapter explaining some elementary biological facts without a knowledge of which the general reader might not be able to understand what follows. Technical words are avoided throughout as far as possible, and the few that are used are explained in the text. We shall reserve for a second notice that part of the book which deals with the problems of human evolution, including the causes of intellectual and moral progress and the means of checking physical degeneration, which is the great practical problem. Here, after a glance at the introductory chapter in which Darwin's theory is outlined, we shall note what the author has to say about Weismann's views, and then proceed to the chapters in which the Lamarckian principle is refuted and the author's own conclusions respecting the operation of natural selection set forth. Two supplementary chapters on sexual selection and isolation should also not be wholly overlooked.

I.

In the introductory chapter, which is intended not for the biologist, but for the general reader, it is pointed out that evolution and Darwinism are not synonymous terms. Darwin gave his theory to the world in 1859; long before this Lamarck had propounded a theory of evolution—that is to say, an unfolding of the higher forms of life, animal and vegetable, from the simplest. According to Lamarck, all species have become what they are through the moulding influence of external conditions (such as food, climate, &c.), and of exercise. From these two sources arise all variations, and characteristics thus acquired are handed down to succeeding generations. This assertion concerning the origin of species was not accepted by men of science. Darwin's work was, not to originate the idea of evolution, but to show by what means evolution had been brought about. This means he called the struggle for existence, to the action of which was attributed an unceasing natural selection. The proposition which he set himself to work out was this: (1) The offspring of all organisms, whether animal or vegetable, tend to resemble their parents. (2) The young are never exactly like their parents, but there is always some variation. The variations are mainly "spontaneous" (by which term Darwin meant that we cannot discover the cause of them), and, *to a less extent, due to the manner of life of the parents and the environment in which they live, characteristics thus acquired being handed down to the next generation*. It is obvious that in the words italicized Darwin gave a qualified assent to the Lamarckian principles, an assent which has been retracted by the Neo-Darwinians. (3) More young are born in every species than would be required to keep up its numbers, supposing that there were no natural check at work to prevent increase. Darwin instanced especially the elephant, which is the slowest of breeders. If allowed to multiply unchecked, elephants would soon people the earth. (4) In the struggle for existence, all favorable variations are singled out for survival by Natural Selection; it acts in the same way as artificial selection. Thus, as the breeder has produced the many varieties of domestic pigeons, nature has produced all the many species of the animal and vegetable kingdom. Finally, Darwin held that Natural Selection is supplemented by sexual selection.

So much for the proposition, the truth of which Darwin undertook to demonstrate. Now let us look at the evidence by which it is supported. This falls into four categories. In the first place, the science of embryology has shown that each individual in one of the higher species of animals goes through, while in the womb, many of the stages through which, according to Darwin's theory, the species has gone in the process of evolution. In scientific language, the author would express the same truth thus: The ontogeny, or the development of the individual, as it proceeds, recapitulates briefly the phylogeny, or history of the evolution of the species. Thus man, while in the womb, is at first a one-celled protozoon, then an agglomeration of undifferentiated cells; at a later stage, he has gill-slits like those of a shark, though no functioning gills. In the second place, palæontology bears witness to an advance from the lower to the higher forms. We find in the primary rock fishes and amphibians, and in the most recent rocks, some reptiles. In the secondary rocks reptiles are dominant on land, in the sea and in the air. Pterodactyls, winged lizards, some small and some large, are kings of the air. Birds, too, are beginning to appear. There is the archæopteryx, a true bird, though with many reptilian characteristics, found as fossil in the Bavarian lithographic stone; the toothed birds of America belong to this period. Small marsupials, allied to the existing kangaroo, are as yet the only mammals. In the Tertiary rocks birds of a less reptilian type are found in every quarter of the globe, but dominant everywhere are the higher mammals, called from the manner of their growth as embryos, placenta. In this period Mr. Headley considers it as proved that man already existed; he had already been developed, according to Darwin's theory, from a lower ape-like form, now extinct. Flint instruments showing unmistakable signs of human workmanship have been found in deposits that belong to a pre-glacial age. Apart from from such proofs, it is pronounced evident, from the stage of development that man had reached at the beginning of the Quaternary period that he must already have been man, properly so-called, in the Tertiary. If now the Tertiary period be subdivided into three sections, we encounter further evidence of evolution. In the first of the three sections, the Eocene, we find animals and plants belonging *to families* now existing. In the second, the Pleiocene, existing *genera* are represented, but not yet *species* that are still extant. Finally, in the third section of the Tertiary period, the Pleistocene, we find animals (among them man) and plants representing *species* that are now living upon the earth. In the Quaternary age existing species are encountered in abundance, and frequent evidence of man appears.

We come in the third place to the testimony of comparative anatomy and comparative physiology. Mr. Headley submits that an impartial anatomist must put man at no great distance from the higher apes, whether their bony skeleton or their bodies generally be compared. Even their brains agree in structure, though in man the development is enormously greater. Comparative physiology shows that the processes of life in all animals are, roughly speaking, the same; all of them take in protoplasm as food; all of them make use of the oxygen in the atmospheric air, or of that dissolved in water, in order to oxidise the tissues they have built up, and so produce heat and energy. There is one mode of reproduction common to all. Proceeding to the fourth and last category of evidence, we observe that the present geographical distribution of animals and plants is explicable on the theory of the gradual evolution of species (beginning at some one centre) and of their gradual dispersal to all accessible regions. Whereas, on the theory of special creation, why have oceanic islands only those animals which had the power of making their way thither over the sea? Of all mammals, why is the bat the only one truly indigenous in New Zealand?

Of these categories of evidence it is obvious that the first and second, that is to say, the masses of testimony drawn from embryology and palæontology, respectively, are the most convincing. On a theory of separate creations the preliminary embryonic stages of man, during which he belongs to various other classes of animals in succession, would be superfluous and unaccountable. The evidence of palæontology compels us to conclude either that there were numbers of separate creations at different periods (mammals, for instance, being introduced when the earth was already peopled with lower forms) or else that evolution has taken place. But embryology forbids us to accept the alternative of separate creations, so that evolution remains as the only possible explanation of the fact.

Mr. Headley also invites attention in his introductory chapter to the argument drawn from artificial selection in support of Darwin's theory. There is no doubt that in the course of many centuries, artificial selection has produced very divergent breeds of horses, cattle, dogs, pigeons, &c. It is true that all the efforts of breeders have not raised from wild horses anything but horses; from the wild rock pigeons anything but pigeons. Breeders have experimented, however, only on species in which specialization had already gone very far, and in which, consequently, the range of variation was narrow, so that we should rather wonder at the greatness of their success than at their comparative failure. Moreover, the time available has been short. Palæolithic man, as far as is known, had no domestic animals. Most of those we have now were domesticated in the Neolithic period, probably less than a million years ago. During the greater part of this time there was, of course, a great want of thoroughness and system about the breeder's methods. Within the last hundred years, many new breeds have been developed and we cannot but feel surprised at the great triumphs of the short period during which science and system have been brought to bear. Nature, the great experimenter, took in hand at the outset unspecialized, and, therefore, more plastic forms, and has continued her experiments for millions of years. It is often objected that man has not produced results in any way similar to those we attribute to Natural Selection, since all his new breeds of pigeons, for instance, are fertile *inter se* and are, therefore, mere varieties, not species. Our author replies that it is probable that this test would condemn a great many wild species, which are kept apart from others by the clannishness of their members, not by genuine inter sterility. It is certain that artificial selection as practised by the breeder is not different in kind from Natural Selection. Unfortunately, the absolutely conclusive experiment, the development of a complex animal from a one-celled organism is altogether beyond man's power. Natural Selection, therefore, remains a reasonable hypothesis that can never be proved, but which commends itself to a majority of competent judges. Among those who support it, however, are some who, while holding that it can account for a great many of the phenomena of the animal and vegetable kingdoms, yet deny that it can account for all.

In the same introductory chapter the author reminds us how curious has been the evolution of opinion on the subject of evolution. Before the publication of Darwin's "Origin of Species," the theory of evolution was much discussed, but was generally rejected by naturalists, as nobody could show what had brought it about. Darwin's Natural Selection was welcomed as a working principle which made it possible. Darwinism, therefore, led men to believe in evolution. A majority, probably a considerable majority, of naturalists are still Darwinians, but there are now not a few who, while accepting evolution, are half inclined to reject Darwinism, to scoff at the bridge by which the scientific world made its way to evolution over a sea of difficulties.

II.

Before marking the author's exposition of Weismann's views, it may be convenient to reverse the order adopted by the author himself and to reproduce, first, his refutation of the Lamarckian principle. To this refutation a chapter is allotted, the purport of which may be thus summed up. It is very difficult even to imagine the means by which acquired characters might be transferred from a bodily organ to the germ-plasm, as Lamarck assumed that they were transferred. We are reminded that breeders scarcely take into consideration the possibility of such transference, and that, even in the case of disease, direct evidence is difficult to find. It may be well to dwell somewhat in detail on these points. The scientific breeder of cattle or of any of our domestic animals stands to his animals in the place of nature. He determines what characteristics shall mark the race, as Nature decides in the case of wild animals. Now breeders, in the Old World, at least, have never trusted much to Lamarckian methods, though some American breeders have evinced Lamarckian tendencies. No breeder of homing pigeons holds that young birds are any the better because their parents have been highly trained before they bring them into the world. If a bird wins a prize in an important race, its offspring, born before it was highly trained, have just as great a market value as those born after.

When a racehorse has made a great name he is often put to the stud, and his training is neglected. He is kept in good health, but there is no attempt further to develop his speed. Breeders then by their practice support Weismann. They may hold, it is true, that a particular diet may produce size, and in this view they are undoubtedly correct. But if they assume that the larger build, due to such food, is inherited, scientists are at liberty to disagree with them. Breeders not only feed for size, but select for it. The whole result may be due to selection, or, to put it more correctly, those individuals are selected in which the diet in question produces large stature. If we turn to plants, the case against Lamarckism is still stronger. A gardener is bound to be mainly a Weismannite. He can, it is true, vary the soil, and so to some extent the diet of his nurslings, but a plant cannot be trained and exercised as a horse can. The gardener must trust to congenital variations. For these he looks out and selects the plants that show the qualities that he wants.

Mr. Headley proceeds to consider the Lamarckian argument that even if the other acquired characters are not transmissible, this can hardly be true of diseases or of immunity from them. He insists that there is convincing evidence that there, too, the rule holds good, that acquired characteristics are not inherited. Among the infectious maladies from which civilized man has suffered for many generations, he singles out measles as a good example for his purpose. Those who have measles are in most cases immune for the rest of their lives. They may come in contact with the germ, but it has no power to injure them. This immunity, however, is not transmitted to the next generation. The members of that generation, on the contrary, are obliged, as their parents were, to purchase each for himself immunity by suffering from the disease. At the same time, while there is no inherited immunity we must not overlook the striking fact that in the course of generations the disease tends to become milder. The Fiji Islanders when first attacked by measles died by hundreds. Even in England the deaths due to measles still amount to a considerable number, but not to any large proportion of the cases. How can an opponent of Lamarck account for this difference between English people and Fiji Islanders? Mr. Headley says that, in the first place, we must allow for the results of careful nursing. He admits, nevertheless, that the whole difference cannot be thus explained. It is evident that a race which for generations past has suffered from a given disease is better able to resist it than a race that is attacked for the first time. This he thinks is certainly best accounted for by the fact that those who were unable to combat the disease have in each generation been weeded out. That is his explanation, and it seems sufficient. "Can the Lamarckians," he asks, "deal with these facts satisfactorily?" He answers: "They may contend that the increased power of resistance, which is generally recognised as existing among Europeans, is the acquired immunity inherited in a modified form. In the case of measles and other infectious diseases, which do confer immunity on the sufferer this may, perhaps, seem to hold. But, in the case of consumption, the explanation breaks down. And a principle, if it is sound, ought to be of general application."

Mr. Headley proceeds to point out that for hundreds of years past consumption has been one of the most destructive diseases in England; in Cromwell's time, as the bills of mortality show, it was prevalent in London. In the present day probably about one in ten of the total of deaths is due to some form of tuberculosis. Its destructiveness, however, among English people is nothing to what it is among savages; if once the germ is introduced among the latter, they have no power to resist it. "Now here," continues Mr. Headley, "the Lamarckian explanation is out of the question. There is no acquired immunity from tuberculosis; a sufferer may be completely cured, yet he is at least as liable to infection as a person who has never been attacked. The comparative superiority, therefore, of Europeans to the disease we are bound to attribute to the constant elimination in past generations of those who were unable to resist it."

If it be difficult to show how a modification acquired during a lifetime can be transmitted from the body to the reproductive cells, it is no less difficult to prove that the inherent character of any organ can be changed by its environment. If children habitually go barefoot, their feet become hard, and this is, no doubt, a modification in the accepted sense of the word; as distinguished, that is, from a variation in the inborn character. Children are born, however, with feet whose nature it is to grow hard, if unprotected; and all that has happened in the case supposed, therefore, is that an existing characteristic has been brought out. If gulls are fed on corn, they will develop something of a gizzard like true gramnivorous birds. Mr. Headley explains this by saying that gulls are born with stomachs capable of becoming highly muscular should the need arrive. A green frog, if he is not among green leaves but amid dull, colorless surroundings, ceases to be bright green and becomes a sombre gray. Put him among foliage again, and his green soon returns. Can it be said that the green foliage has caused his color to change? Our author deems it more correct to say that the frog has the power of changing his color to suit his environment. If the frog happens to be blind, no change of color takes place; it is by the help of the eye and the nervous system that the change is effected. Many animals live their whole life long in evergreen forests, and yet their skin, hair or feathers show not a speck or tinge of green. They have no susceptibility to this particular kind of stimulus. When the American hare turns white in winter, its old hairs lose their color, the change usually beginning at the tip, and a great many new completely white hairs appear. Manifestly, the animal has the power of turning white when the cold season comes on, and of producing a fresh crop of white hair to keep itself warm. It is difficult to see how the cold could cause hair to grow or change color, unless the animal in question had the power of reacting to this particular stimulus. "In fact, an external condition can do nothing but bring to light some latent quality. Speaking casually and unscientifically, we may say that being a member of the House of Commons has made so-and-so a fine debater. To put it more correctly, it has developed a power that was already there. Weismann expresses the truth as follows: 'Nothing can arise in an organism unless the predisposition to it is preëxistent, for every acquired character is simply the reaction of the organism upon a certain stimulus.'"

What can exercise have to do with the origination of organs? It is obvious that a limb may be strengthened. The disciples of Sandow are continually developing the particular muscles that they want to develop. The lungs may be strengthened by singing or by systematic breathing exercises. The voice will become much stronger if constantly used in the proper way. A wonderful approach to perfection in the coördination of muscles may be achieved by practice, with the result that athletic records, deemed insuperable, may be broken. But how if we wish to originate a new organ? Let us hear Mr. Headley on this point: "Without engaging in any definite speculations as to the mammalian pedigree, we may feel sure that there was a time when the ancestors of mammals had no limbs, nor even continuous fins from which limbs were to develop. How can you exercise what does not exist? On Lamarckian principles you can in theory account for the improvement and specialization of a limb as the generations go by. But when it is a question of the *origination* of any organ the theory collapses, even if we allow the big assumptions that are made. How did the sense of hearing begin? Exercise failing us, we have here to fall back on external conditions. This means that sounds, striking against the skin, stimulated it to sensitiveness and developed the requisite nerves. If the skin could be so stimulated it must have been already sensitive, must have already possessed some rudimentary acoustic machinery. This is the conclusion at which we arrived before, that external conditions can originate nothing. We find now that the same thing is wholly true of exercise; it is only a stimulus to which the organism responds; it can help a man to attain the maximum development of brain or body of which he is capable. It can give him nothing that was not potentially his at birth."

That exercise is not necessary for growth is evident from the fact that, in many cases, growth proceeds entirely without exercise. The tree stands motionless and grows; its sap flows, but there is nothing that can reasonably be called exercise. For growth pure and simple exercise is not wanted by an animal any more than it is by a vegetable. A chicken within the egg has little opportunity for taking exercise; yet, cramped in his narrow prison, he goes through the most important stages of development, and at length emerges able to move about, endowed with something in the way of instinct, and with brain sufficient to learn quickly from his mother's teaching. The embryo of any of the higher mammals passes through a marvellous series of changes, and is structurally not far from the mature phase when at length it sees the light and knows the delights of exercise and play. Manifestly, then, embryology is not at the disposal of Lamarckism.

If the origin of an organ cannot be ascribed to exercise, neither can the disuse of an organ, even if almost complete, arrest development altogether. It certainly does not. Even when, for intelligible reasons, growth has become associated with constant exercise, we do not find a very great shortcoming in a particular organ of which little use is made. In some breeds of domestic ducks that have given up the habit of flight, the wing bones (humerus, radius, carpo-metacarpus) are in actual measurement longer than in the wild duck, though shorter relatively to the leg bones. No doubt the wing development of domestic ducks is less than it would be with more active habits. But the reduction is not very great, and we are reminded that the huge weight of the Aylesbury duck, for instance, as compared with the wild duck, is due to a general increase in size, and that in this increase the breast muscles—that is, the muscles of flight—have shared, the breast bone from which they spring being much larger than in the wild ancestors of the breed. Selection for bulk has brought about an increase of the flight muscles, in spite of their disuse.

In connection with this branch of the topic, Mr. Headley discusses the question of the rudimentary or vestigial organs. Examples are easy to find. Man is still possessed of muscles for moving his ears forward, though he has altogether lost the use of them. The apteryx, or kiwi, the New Zealand bird that has lost the power of flight, has still beneath its feathers the chief wing bone reduced to minute dimensions. The python has tiny hind legs bearing claws that just appear through the skin. The blind crayfish have eye-stalks, and some vestiges of eyes, though their sight has gone. Mr. Headley takes the apteryx with its much reduced wings as a typical example of such phenomena. "Suppose the reduction of the size in the wing to be due to disuse. Then in the early stages when disuse was incomplete, the process of reduction would be very slow. But, when the wing had become so small that exercise was out of the question, then, on Lamarckian principles, we should have expected all trace of it to disappear rapidly. Now this is just what in this and hundreds of like cases we do not find. When once an organ has been reduced to the point of absolute uselessness, it often lingers on with astonishing persistence, though there are, it is true, many examples of complete disappearance. Thus, of the five digits of the normal hand, the bird has only three remaining, and of the two missing, probably only one is represented by a trace in the embryo." It is submitted that such instances of complete loss as these do not in the least stand in the way of our author's argument, which is this: "If partial disuse can greatly reduce an organ, complete disuse ought in every case to cause its total and comparatively rapid disappearance. If it be urged that all vestiges are gradually vanishing, the answer is that in many cases organs reached the vestigial state ages ago, yet still they linger on. For ages the horse's forefoot has borne only one toe, and yet there still remain the two so-called split bones that once carried a toe on either side." It seems, then, that the Lamarckian explanation of vestiges fails to explain the facts.

Inasmuch, however, as Mr. Herbert Spencer has written much upon this subject, our author takes up some other problems which Lamarckism fails to solve. To Mr. Spencer the great antlers and the great development of muscle and ligament for carrying them present a phenomenon which can only be accounted for, if the various associated developments be considered as the inherited results of exercise. We can imagine, he says, that congenital variations might be accumulated and the antlers by themselves be accounted for in this way. But they would be an insupportable burden, did not other variations arise simultaneously, giving the body the strength to carry so great a weight. Such coadaptation and coöperation can be explained, Mr. Spencer contends, only on Lamarckian principles. Our author admits that the position here taken by Mr. Spencer is a very strong one. The problem which he has presented to the Neo-Darwinians, that is, to those Darwinians who have thrown overboard Lamarckism, is not an easy one. It is in another chapter, to which we shall presently refer, that Mr. Headley undertakes to show how Natural Selection, unassisted, can deal with it. For the moment, he merely points out that in one respect Mr. Spencer's position is entirely untenable. "The antlers themselves, Lamarckians hold, originated from the fights of rival bucks. The bucks were constantly butting each other, and the bone of the skull thickened at the place which was most butted. Hence the antlers of, for instance, the wapiti deer. We may assume, what I have tried to show is impossible, that constant blows could produce thickness of bone, instead of merely stimulating the bone to put forth what power of thickening it had. Granting this, we have next to assume that mere random knocks could produce the beautiful symmetrical branching of the antlers. Was there systematic hammering at the point where a branch or tine was to arise? But, if this view of the antler is discarded, and they are attributed to Natural Selection acting upon congenital variations, while the supporting muscles are explained as the inherited result of exercise, then we have two principles, which, to say the least of it, are not very good yoke fellows, expected to pull together." The relevant passage in the chapter to which we have alluded runs as follows (page 122): "Imagine the wapiti deer, or rather one of his progenitors—this is the old puzzle set to Neo-Darwinians by Mr. Herbert Spencer—developing great antlers through the accumulation of congenital variations by Natural Selection. What if the muscles and ligaments of the neck and of all the coöperative machinery did not grow strong through favorable variations during the same period? The answer is plain enough; even without the help of Natural Selection the organism will be able to make shift for a time. Muscles can be strengthened by use during the lifetime of an individual. How much can be done in this way, if we begin, say in our teens and exercise certain muscles regularly for half an hour a day? How much greater would be the result, if we exercised them each day during the whole time that we were on our legs. All day the stag was carrying his antlers, and his muscles were acquiring the strength that was needed. But when the antlers in the course of many generations had grown big, males that were born without specially adapted muscles to carry them would not be likely to be lords of the herd. So that, here, too, congenital variations would follow in the wake of accommodations, due to exercise in the individuals."

Still pursuing the argument against the Lamarckian principle, the author reminds us that the explanation of the skill of neuter insects has been a familiar problem since Darwin's time. The wonderful architecture of the cells made by bees has impressed everyone who has thought of the matter. Now, the skill of the worker bee is born in her; it is not due to a laborious education. Neither can it be that skill acquired through practice by former generations of workers has been transmitted as an instinct to the bees whom we watch at work. The worker bee leaves no offspring behind her. The whole hive are the children of one queen. She herself displays no skill, except in depositing her eggs and in carefully distinguishing between those that are to develop into drones or into workers. She is no builder, like the ordinary working members of the hive. If, on occasion, intelligent adjustment to new conditions is required—a modification of the stereotyped architecture to suit a novel situation—it is the neuters who come to the front, and subsequent generations cannot possibly inherit the acumen and resourcefulness that result from such exercise of the faculties. How has this difficulty been met by Lamarckians? The bees, they say, gained their skill before the division of labor in the hive was carried so far, before all the egg-laying was done by one female only, at a time when each female not only worked but also produced offspring. But, asks Mr. Headley, is it not reasonable to suppose that the improvement in skill has gone on hand in hand with the division of labor? Surely, he continues, the same principle to which the development of this skill is due must now be maintaining it. If practice has produced results so extraordinary, how does it happen that there is no deterioration, though, for an enormous succession of generations, the parents, male and female, have given up all practice of the art? Our author next selects from insect life two or three examples of a wonderful phenomenon. The fact is recalled that certain insects have once only in their lives to do work that requires the utmost skill. When a caterpillar has grown to its full size it is time for him to make a chrysalis, and, if he does not make a really good one, he has little chance of ever emerging as a butterfly or moth. Some cocoons are spun in an extremely clever way, and Mr. Headley lays stress upon the point that the skill cannot be the inherited result of practice. We repeat that once and once only does the caterpillar try his hand at such work; yet very beautifully he does it. Familiarity has dulled us to the marvel of the phenomenon. Extraordinary, however, as is the spinning of the cocoon by the caterpillar of the common silk moth, the feat is nothing compared with what is done by a California moth, a full account of which is given in Kerner's "Natural History of Plants." The caterpillar of this moth lives on the seed of the Yucca plant; this plant cannot fertilize itself, but must have pollen brought to the stigma. The Yucca moth, armed with special appliances, not only deposits its eggs where the caterpillars, when they emerge, will have proper food, but accomplishes the transfer of the pollen. At night when the yellowish white flowers are open and visible in the moonlight, she starts forth on the business on which depends the continuance of her race. She enters the bell of a flower and collects a ball of pollen. For this purpose the Yucca moth makes use of the elongated first joint of the maxillary palp, "the inner surface of which is beset with stiff bristles, and can be rolled up like a trunk." With this she seizes the pollen and rolls it into a ball which is sometimes three times as large as her head. She then flies to another flower and proceeds to deposit her egg at the base (which in a hanging flower is uppermost) of the pistil. This she does by means of an ovipositor consisting of four horny bristles which are able to pierce the hard tissue. Having laid her eggs, she goes to the top of the funnel-shaped pistil and stuffs the pollen into the mouth of the funnel.

Mr. Headley directs particular attention to various points that strike one as he reads this remarkable story: First, the adaptation of the maxillary palp and the ovipositor; second, the correct use of the special apparatus; third, the fact that the individual moth gains nothing by the whole business; fourth, the fact that each moth has only once in its lifetime to do this work. The circumstances seem to make it impossible that there can be any imitation, any learning on the part of one individual from another. In the presence of such facts what, inquires our author, becomes of the Lamarckian hypothesis?

Now, let us sum up the outcome of Mr. Headley's chapter in which the Lamarckian principle is refuted. We repeat that he has here essayed to prove that it is extremely difficult even to imagine the means by which acquired characters might be transferred from a bodily organ to the germ plasm. He has pointed out that breeders hardly take into consideration the possibility of such transference, and that even in the case of disease direct evidence of such transference is hard to find. He has tried to demonstrate that neither exercise nor external conditions can change the nature of any organism, but can only develop characters that are already present. "Every acquired character is," as Weismann has put it, "simply the reaction of the organism upon a certain stimulus." No organ can be originated by exercise, though an existing organ may be developed to its maximum. The Lamarckian view of exercise is incorrect. Growth does not depend on exercise, except under certain circumstances, where the association of the two may be easily explained. However close, too, the correspondence between an animal or plant and its environment, it is easy in many cases to show that the adaptation which has arisen cannot possibly be due to the direct action of the environment. Lamarckism fails to account for the antlers of the stag, for the skill of the worker bee, for the cocoon spinning of the caterpillar or the remarkable instinct of the Yucca moth. In some cases the Lamarckian principle cannot possibly be applied, and we have even in one and the same animal to imagine it working side by side with a principle that, if not actually antagonistic, is yet incongruous.

Again, the reproduction of lost parts by embryos shows that the organism, even in the embryonic stage, follows its own course and is not the creature of circumstances. The argument that variations may and must be caused by diet is unsound. The organism does not passively submit to the influence of any diet that may be served up to it, but selects in accordance with its own inherited character, and this character has been inherited equally by the germ plasm. Mr. Headley submits that, if there be any force in what he has here urged, Lamarckism fails to make good either of its contentions. First, it cannot account for the origin of variations; secondly, even if we grant for the sake of argument that there are such things as acquired characteristics, the evidence of their transmission is untrustworthy; the machinery in the organism by means of which they can be transmitted has yet to be discovered.

III.

It is in a chapter on "Heredity, Variation and Death" that our author undertakes to formulate in a few compact and lucid paragraphs Prof. Weismann's famous theory of the continuity of the germ plasm. It is obvious that the oak, the giant of the forest, is potentially in the tiny acorn from which it has sprung. In the same way, the chicken must be potentially in the egg before incubation has taken place, although no chicken is to be seen. Here, however, another question arises: An egg is the mother of the hen, but is a hen the mother of the egg she lays? Weismann answers: "Certainly not:" and the world is coming to agree with him. The egg and the hen that lays it are both sprung from the same egg. In the line of descent egg follows egg; each, if it hatches, becomes the mother of a chick, and, if the chick be a hen bird, of other eggs also that may in time be laid and duly sat upon and hatched. This is the hypothesis that Weismann has spent years in maintaining, and, inasmuch as the inferences to be drawn from it are of the utmost importance, our author endeavors to state his premises and deductions with the utmost succinctness and perspicuity. We quote a part of our author's extremely condensed synopsis: "The nucleus of the reproductive cell bears all the hereditary characters, and it is almost certain that it is not the whole nucleus, but the loops of chromatin that have this function; observation shows that they are the essential part, the astrosphere (the small, starlike body discernible in the nucleus), merely supplying motive power. When the egg is maturing we see that the nucleus is divided by an elaborate process, and one resultant half, the first polar body, is expelled from the cell. After this there follows a repetition of the process, and a second polar body is thrust out [for the illustrations which exhibit this process we must refer the reader to page 14 of the book before us]. The former of these divisions has for its object the rearrangement of the particles that make up the germ plasm, that part of the nucleus by which heredity is maintained and which is formed of the various chromatin loops. The second division reduces the amount of plasm and reduces the number of hereditary characters to one-half. This reduction must take place, since the egg is to be fertilized, without any increase in the number of the essential particles. When parthenogenesis (birth from unfertilized eggs) takes place, as, for instance, in aphides and bees, only one polar body is got rid of. The division of the nucleus that results in this case is a rearrangement of material with a view to variation, since without variation there would be no evolution. No second polar body is in this case extruded, because whenever parthenogensis is to take place there is no need to reduce the plasm to half its amount. It has been held that the ejection of the second polar body leaves the egg female in character, whereas formerly it had contained the elements of both sexes. The fact that male traits are often handed down through the female, and vice versa, disproves this idea. It is true that the egg has sexual characteristics (such as food for the embryo), but the germ plasm has none. Sex is a secondary character in the offspring. Experiments on tadpoles, caterpillars and rotifers have shown that food and temperature are factors in determining it." We should here note that if the egg is the scene of two nuclear divisions, one leading to modifications in the arrangement of characters, the other to a reduction in the amount of the plasm, similar phenomena ought to be observable in the maturation of the male or sperm cell. This has been shown to be true of the sperm cells of ascaris, a nematode worm; there are two cell divisions; as in the egg, the amount of the chromatin is reduced by one-half, and here, too, the germ plasm is non-sexual; the sexual characteristics of the cell are secondary.

We go on with Mr. Headley's concise exposition of Weismann's hypothesis. Strive as he may he finds it impossible entirely to avoid the use of Weismann's technical terms. "Each of the two cells [masculine and feminine] that are to fuse is made up of minute vital particles called *biophors*; these combine together to form *determinants*, each representing a bodily characteristic, and these determinants are grouped into *ids*. The cell not only contains thousands of determinants or characters—each part of the body that has a character of its own must have its own determinant—but it must have, besides that, a definite architecture. Each of the combining cells has a very similar but not the same architecture, and the object of the fusing of the two is to produce variations, without which we should not be able to account for the evolution of different species. The fusing is certainly not a vitalizing process, producing rejuvenescence, for is has been shown that in the unicellular organisms the corresponding process, conjugation, very much delays reproduction by fission. Parthenogenesis proves that an egg without fertilization is capable of reproduction." But, as our author goes on to remind us, "Natural Selection could not go on without variations, and in conjugation and sexual union is the chief source from which variations arise. In unicellular organisms, it is true, variations are largely due to external conditions, but this cause is of quite minor importance among the metazoa, for in them the reproductive cells are isolated, and it is important to remember that the environment can only affect the germ cells by acting *directly* upon them. In parthenogenetic eggs, if we neglect the insignificant influence of external conditions, the preliminary division of the nucleus is the only source of variations, and it is found that animals born from such eggs do vary to a certain extent. Far less diversity, however, is likely to result in this way. Hence have arisen conjugation and sexual union; they supply to Natural Selection the variations which it requires as its raw material; the production of variations is their sole *raison d'être*. In the diptera (among them our common flies) certain cells, containing unaltered germ plasm, are from the first set apart. In other cases the separation takes place later in the course of development—in the hydra even after the formation of a fresh person or individual (neither term is quite satisfactory) by budding. Nevertheless, the part separated is a part of the original germ plasm." A sharp distinction must be drawn between the germ cells and the soma, or aggregate of non-reproductive cells; that is to say, between the germ cells whose function is reproductive and all the other cells of which an individual is composed. "From a fertilized germ-cell springs a new individual; in this individual, germ plasm is set apart unaltered, and so the race is continued. From the isolation of the germ cells it follows that only by a process very difficult to imagine can characteristics acquired by the *soma* be transferred to them. All variations originate in the germ plasm." Once more: "Death is the result of Natural Selection; the species that were cumbered with aged or out-of-date individuals were at a disadvantage, and disappeared. Sexual reproduction is a means not of restoring lost vigor, but of producing variations. Favorable variations would obviously be of advantage to the species. Those individuals that multiplied by fission only, though potentially immortal, disappeared in the struggle for existence because the resultant cells, when they divided, showed fewer variations, and so were not so well constituted for the establishment of new species."

After having thus rounded off his hypothesis and maintained it in the teeth of all objectors, Weismann proceeded in his book "The Germ Plasm, a Theory of Heredity," to modify his view of the significance of amphimixis, a term which by his definition includes both conjugation and sexual union. Amphimixis suddenly ceased to be the prime cause of variation. "The cause," Weismann now said, "must lie deeper than this; it must be due to the direct action of external conditions on the biophors and determinants" (in the reproduction cells, not in the soma). He had already recognized such direct external influences on the germ plasm as a minor cause of change. But amphimixis had always ranked as first in importance. Now it seems suddenly condemned to play second fiddle; it only combines variations, it does not originate them. Why this sudden change? It is attributed by Mr. Headley to a breakdown of the elaborate Weismannite architecture of the germ plasm—the biophors, determinants, ids and idants. A highly complex animal must have more determinants than a less complex one, and Weismann could not see how amphimixis alone could cause a multiplication of them. Our author suggests "that the whole difficulty has its origin in the attempt to explain the inexplicable architecture of the germ plasm. Surely, it would have been enough to say that the architecture is somehow there, whether we can picture it to ourselves or not. As to variations, we know that crossing does not produce them, and since no two individuals are exactly alike, every union is of the nature of a cross. This being so, I cannot help regarding Weismann's earlier views upon the significance of amphimixis as worthier of him than this later phase."

Mr. Headley believes that he has stated Weismann's views fairly, and he has certainly tried to make them clear. He admits that they contain strange paradoxes that have excited ridicule, and that Weismann's shifts, refinements and modifications, his endless manufacture and elaboration of hypothesis and supplementary hypotheses, must be reckoned among the most serious ills that a biologist at the present day is heir to. Moreover, he seems at times, through carelessness of expression, to deify Natural Selection and endow it with creative power. A careful reading of his essays, however, will remove this first impression, though, short of actual creating, he assumes that it can do anything and everything. What solid result is there? That is the important question. Let us hear Mr. Headley answer it: "An impartial critic must own that from all Weismann's theorizing there emerges one great idea of the utmost value as a basis for a theory of heredity—the continuity of the germ plasm. This doctrine once established, the non-inheritance of the modifications of the *soma*, due to exercise or external conditions, though not a logical deduction from it, yet becomes a probability. Round the question of heredity there still rages a turmoil of angry controversy, but, though the clamor does not diminish, there is less divergence of view. The rival theories tend to approximate to Weismann's, and, in spite of all the strife and hurly-burly, the continuity of the germ plasm holds the field."

The theory rests on a firm foundation. We know that the nucleus of the germ cell contains, closely packed, all the characters of the animal that is to grow therefrom. If part of the germ plasm remains undisintegrated, its architecture unshattered; if the germ cells are separated off from the rest of the body (that is to say, from the soma), except in so far as they receive nourishment from it; if in their seclusion they continue to multiply by fission, each resultant half containing the same characters, all else in their life being merely the assimilation of food—then we can understand how parental and distant ancestral traits can be transmitted. But, if the particles that represent characters were scattered all over the body, how could they be recollected and replaced, each in its proper position? Such a thing would puzzle the wildest imagination. We are driven, then, to conclude that germ plasm is kept unaltered, and that from it springs the next generation. After setting forth the rival theories Mr. Headley expresses the conviction that, so far as the continuity of the germ plasm is concerned, Weismann has successfully maintained his position.

IV.

So much for Weismannism. The conclusions at which our author, who, although a Neo-Darwinian, does not concur with Weismann in all particulars, ultimately arrives will be found summed up on page 152. Here we are called upon to note, in the first place, that the struggle for existence which is always going on is not always a struggle among individuals. Very frequently there is mutual help among the members of a group which only by means thereof is able to hold its own. The stress is felt only at recurrent crises; an animal must be able to face these emergencies, if he is to survive. During the pauses in the struggle the survivors have a superabundance of vigor. Attention is next directed to the fact that, though Natural Selection is always acting by means of the struggle for existence, yet certain characters, which, though useless, are harmless, sometimes survive and remain constant, or fairly constant. Hence the extraordinary number of species of willows and briars in the British Isles and of shells in the Sandwich Islands. Again, the variations on which Natural Selection has to work are usually small, but occasionally large; even very slight differences may cause survival or destruction. There is not wanting evidence that the tendency to retrogression would be, but for the constant elimination of the inferior, stronger than the forward tendency. Weismann is pronounced right in holding that pammixis (free intercrossing) can undo the work of Natural Selection, even without the aid of Reversed Selection.

The shedding of characters that have become useless and cumbersome is one of the conditions of evolution. The addition of new organs is accompanied by the disappearance or reduction to the minutest dimensions of such as have become obsolete. A number of species are evolved simultaneously. A forward step in the one necessitates an advance in those that come in contact with them. Nothing but change of environment can lead to further evolution; when the conditions remain the same, elimination tends only to produce organic stability. The pace of evolution was varied at different periods. It is possible that among certain species, at certain times, in certain regions a condition of equilibrium may be attained, so that in these species nothing beyond greater stability may be in process of evolution. On all sides now, for instance, there are highly specialized organisms, and this makes it impossible that the circumstances under which evolution began can ever be reproduced. In the lower species much of the elimination is indiscriminate, the fit and the unfit being alike destroyed; the amount of such waste is much reduced among the higher plants by machinery which secures the safe transference of pollen and the scattering of their seeds. Among the higher animals waste is checked by a far more effective system, to wit, by the care of parents for their offspring during their immaturity. The struggle comes when the growth has brought out and developed small innate points of superiority and given them selection value. Exercise and play coördinate muscular activities, so that the machinery works without jarring. Play is a rehearsal of the serious business of life, and by fostering intelligence and skill further tends to make the issue of the coming struggle depend on merit and not mere chance. Following Prof. Mark Baldwin and Prof. Lloyd Morgan, our author shows that exercise has another important influence. It is demonstrated in the book before us that exercise may so raise the value of some small congenital variation that it decides the question of survival or non-survival. Hence individuals owing to modifications brought about during the ontogeny or individual life, may make shift to meet new circumstances for which by natural endowments they were imperfectly prepared. Race variations will pursue the direction pointed out by these modifications. Only in the light of this principle are we able to understand the full significance of the education and training of the young by their parents. The principle directs to some extent the working of natural selection, and, consequently, the line along which evolution proceeds, since the determination of habits and of the conditions of life is the determination of the qualities in virtue of which the species shall survive.

It may be asked, is not the principle just explained a reconciliation of the views of Lamarck and Weismann? No, answers our author, for the principle rejects the Lamarckian explanation of the origin of variations. "It even strengthens the position of the Neo-Darwinians by showing that Natural Selection can, without any surrender, make use of Lamarckian methods. For it we may claim that it hastens the process of evolution by keeping a species on its line of development, at the same time leaving it plastic, intelligence to a great extent taking the place of rigid instinct. It fails, however to account for *the appearance of the right variation in the right place*, insuring only that the variation is made the most of when it appears." How are we to explain what seems to be the fact, that there are not in each generation thousands of variations, and all of them ill-suited to the conditions? Mr. Headley replies: "No species can suddenly get rid of the character which its long phylogeny, or species life, has given it. Heredity limits the range of variations, unless there is reversion; and this can proceed far only through the adoption of a parasitic life, or by retirement to sequestered regions where the stress of competition is less severe. None the less does heredity govern the environment; for the important factors in the environment are, as a rule, the competing species, and these have been evolved *pari passu* with that particular species whose evolution we are considering. Thus in the matter of variations the field of chance is limited, nor is it an utterly chance environment to which the adaptation has to be effected. There are limits on either side, but within these limits chance has free play; an adaptation is a coincidence. Nor is there, apart from selection, a definite tendency. It is true that breeders and gardeners have found that, if a variation appears and is preserved by selection, greater variations in the same direction are likely soon to show themselves. There is nothing antagonistic to Darwinism in this. At every step selection must clinch the new development. It follows that mere isolation could not, by allowing a fair field to an incipient variety, bring about much further evolution."

The further specialization has proceeded, the narrower has become the range within which chance has been allowed to operate. Lastly, Natural Selection is only a regulating principle, not a force; it has but guided the evolution of living organisms. Logic compels the evolutionist to assume a force that was not evolved, but which existed before evolution began.

V.

In the penultimate chapter of the first part of this work, the author shows that sexual selection, when its working is rightly understood, accounts satisfactorily for the secondary sexual character, even the most extravagant. No other theory attempts to explain the steady accumulation, generation after generation, of each advance in brilliancy of hue. Not only are secondary sexual characteristics accounted for by Darwin's theory of sexual selection, but the supremacy of Natural Selection is not interfered with. Individuals may be sacrificed, but the species is the gainer. Where polygamy exists, the system works most freely, and there its services to evolution must obviously be great; it must lead to an increase of vigor, since, in each generation, only the very pick of the males leave any progeny behind them. "Sexual selection, rightly understood, does not conflict with Natural Selection, but leaves it in its supreme position. The secondary male characters, even if they cost some strong individual his life, are yet advantageous to the species. For, by captivating the hen birds, they help to bring it about that the very cream of the males are the sires of all the next generation. Thus vigor—though not in the form of showiness—is transmitted to the females who have to rear and defend the young. The courage with which a mother bird defends her nestlings is derived from the line of pugnacious males from which she is sprung. Thus the species gains by what might appear mere dandified adornment and a mere fire-eating spirit."

The last chapter of the first part is devoted to a review of the effects of isolation. Our author holds that Darwin never appreciated the importance of isolation, believing firmly as he did, that divergent evolution, the splitting of one species into several, might take place without it. This seems all the more curious, when we reflect that Darwin always talked of Natural Selection from the viewpoint of a breeder of animals; and no breeder would deem of dispensing with isolation. The breeder picks out the animals that show in the highest degree the points he wishes to develop and keeps them apart from all the rest. Romanes made it clear that, if Natural Selection worked without isolation, only monotypic evolution, or, in other words, the production of one new species, would result. Dr. Russel Wallace divides evolutionists into those who consider isolation "a very important factor," and those who consider it "essential." Mr. Headley, for his part, finds it difficult to see how it can be anything but essential. He thinks that the difference of opinion should be ascribed to the fact that isolation, when not due to some definite, easily recognizable barrier, is not counted as isolation. It is important, therefore, to note what various forms of it are in operation. First, there is geographical isolation. Of this the dodo on his island afforded a good example; it was owing to his living a life apart where there were no carnivorous mammals to make flight a necessity that he lost his wing power. Had there been constant fresh arrivals of birds of his species, intercrossing would have maintained his power of flight and enabled him to escape from the conscienceless sailors who exterminated him. Among the higher animals isolation is probably due to preference. Some difference in color or marking arises by which sympathy is bred, and then those in whom this marking is found herd together and form a race that may in time develop into a species kept apart by what may be called clannish isolation. Thus recognition marks are of the highest consequence. Call notes, the cries peculiar to a species, answer the same purpose as recognition marks, and are often alternative to them. Of this kind of isolation some account is given in this book, and there is also a description of another kind, which operates very generally in the vegetable world, and probably among the lower animals. This latter form is sterility between species, due to differences in the reproductive cells. Mr. Headley regards intersterility as arising simultaneously with beneficial variations, and protecting them from the effects of intercrossing. Among the higher classes of animals it is probable that clannish isolation often replaces intersterility, but, without numbers of experiments it is impossible to speak positively. Experiments are very difficult; if animals of two different species are crossed, there may be perfectly healthy offspring, and yet the species may be intersterile. For the progeny may be mules, and incapable of continuing their race. Our author has no doubt, however, that "intersterility among wild species is by no means invariable. Our domestic cattle are descended from various wild stocks. At the zoological gardens some success has been attained in crossing the bison with the yak and the gayal, and it is much to be regretted that such experiments have not been more frequently made and carried out more systematically." The conclusion is that isolation in some form there must be. The stability of a species cannot be maintained without it.

We have here confined ourselves to that part of Mr. Headley's work which deals with the problems of evolution in general. At another time we shall direct attention to that part of the book in which he enters upon the field which Mr. Herbert Spencer has surveyed, the field, that is, in which the problems of human evolution, including the questions of physical degeneration, of intellectual and moral evolution and of progress in civilization are considered.

M. W. H.